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Department of Mechanical Engineering

Mrs: G Anitha, Asst. Professor,

Subject: Metrology And Machines

Code: ME3103PC

UNIT-1

Metal cutting

Introduction

Metal cutting is the process of producing a job by removing a layer of unwanted material from a given work piece. of a typical metal cutting process in which a wedge shaped, sharp edged tool is set to a certain depth of cut and relatives to our the work piece.

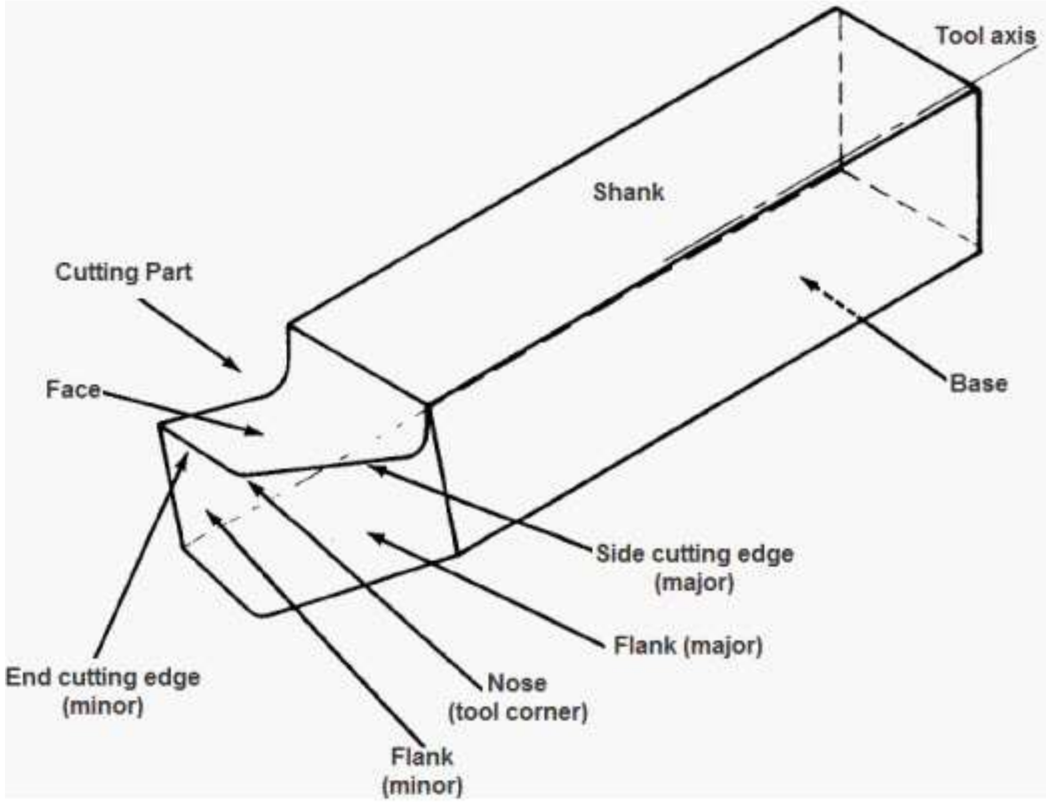
ELEMENTS OF CUTTING PROCESS

The basic elements involved in this process are:(i) A block of metal (work piece).(ii) Cutting Tool.(iii) Machine Tool.(iv) Cutting Fluid.

Geometry of single point cutting tool.

A single point cutting tool consists of a solitary cutting edge, typically made of high-speed steel, carbide, or other robust materials. It is designed to remove material from a workpiece with precision and efficiency.

Geometry of single point cutting tool



Shank:

The shank refers to the clamped section of the tool, constituting the main body situated beside the cutting point. Held securely by the tool post, it provides stability and support to the cutting tool during machining operations.

Side Relief Angle:

The side relief angle represents the angle formed by the side flank concerning the plane perpendicular to the base. Designed to offer relief to the tool, this angle prevents friction between the tool and the workpiece, as well as any unwanted contact between them.

Face:

The face of the tool is the top surface over which the chips slide after the cutting process. Positioned horizontally adjacent to the cutting edges, it plays a crucial role in guiding and directing the metal chips away from the workpiece.

5. <u>Heel</u> –

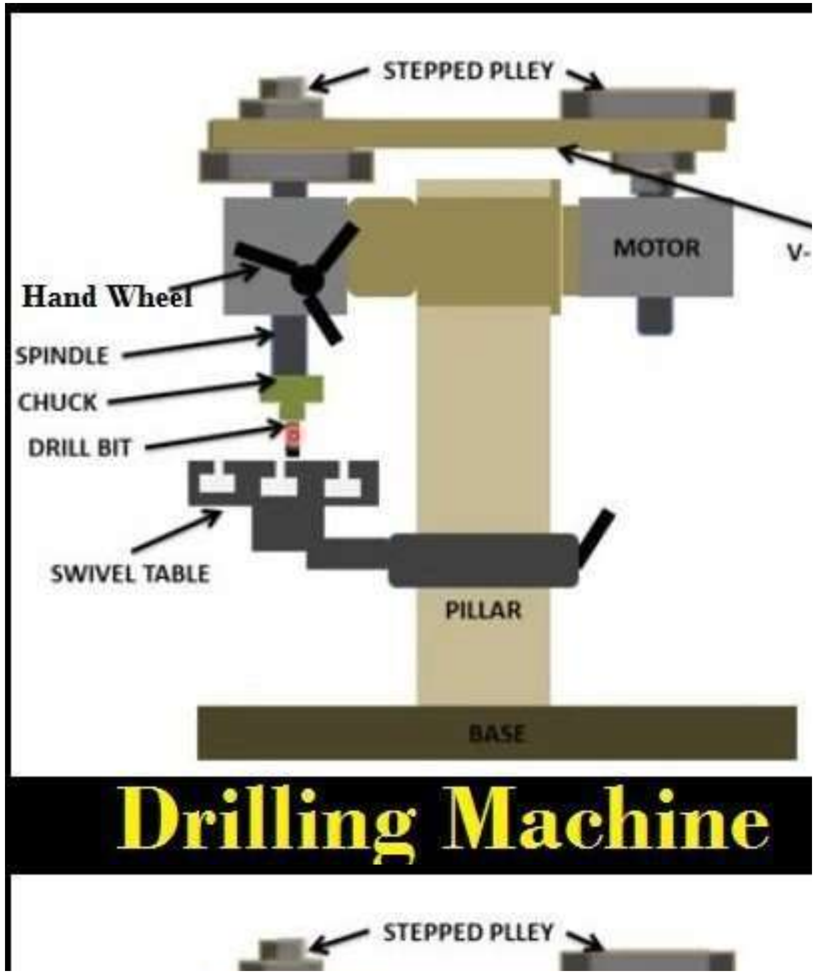
A line of intersection of flank and base surfaces is known as the Heel of a single-point cutting tool.

UNIT 2

DRILLING BORING MACHINES

Introduction

boring machine, device for producing smooth and accurate holes in a workpiece by enlarging existing holes with a bore, which may bear a single cutting tip of steel, cemented carbide, or diamond or may be a small grinding wheel.


STEPPED PLLEY
MOTOR
V-
Hand Wheel
SPINDLE
CHUCK
DRILL BIT
SWIVEL TABLE
PILLAR
BASE
Drilling Machine
STEPPED PLLEY

Drilling Machine: It is a machine which is used to drill the holes on the components or workpiece with the help of drill bits.

The drill bits are also called as Multi-point cutting tools which can have their rapid impact on the Material Removal Rate (MRR) i.e. a single point cutting tool(like the one used in a lathe machine) can removes the material slowly whereas, a multi-point cutting tool removes the material at a faster rate and thereby increases MRR.
2.Construction of Drilling Machine:

The parts are as follows.

1.Base(Bed):the base is made up of Cast Iron which has the capability of high compressive strength, good wear resistance and good absorbing capability(i.e. absorb the vibrations induced during working condition) and for these reasons, it acts as a base to the **drilling machine.**

2.Column: It is exactly placed at the center of the base which can act as a support for rotating the Swivel table and holding the power transmission system.

3.Swivel Table: It is attached to the column which can hold the machine vice in the grips and thereby, the work piece is fixed in the machine vice to carry out the drilling operation.

4.Power Transmission system:

It consists of motor, stepped pulley, V-belt and the Spindle. The power transmission is explained in the working of the drilling machine.

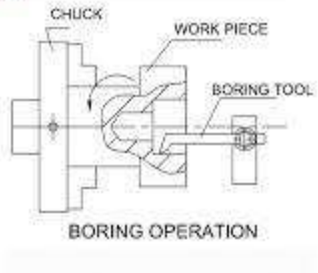
5.Hand wheel

:the rotation of hand-wheel, the spindle moves up and down in the vertical direction in order to give the necessary amount of feed to the work.

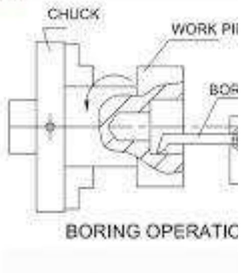
3.Working Principle of Drilling Machine:

1 When the power is given to the motor, the spindle rotates and thereby the stepped pulley attached to it also rotates.
2 On the other end, one more stepped pulley is attached and that is inverted to increase or decrease the speed of the rotational motion.
Now, a V-belt is placed in between the stepped pulleys so as to drive
3 the power transmission. Here a V-belt is used instead of a flat belt, in order to increase the power efficiency.
Now the drill bit also rotates
4which was placed in the chuck and which was in connection with the spindle.
5 As the Pulleys rotates, the spindle also rotates which can rotate the drill bit.

Boring on lathe machine



Boring on lathe mach



principle of working borking machine :

The boring process involves carefully placing the machine's head into the already drilled or cast hole.The device then starts to widen the hole by slowly scraping away portions of the inner wall. The boring tools are similar to those of lathes used in turning and milling machines

During manufacturing, materials must pass through a series of cutting processes that modify them till the end product is produced. Some parts may require holes in the material.

A typical technique to put these holes in the material is boring machining. Though other operations, like drilling, can create holes in a workpiece. CNC boring is the most suitable for making wide diameter holes with high dimensional accuracy.

In this article, we'd discuss extensively boring machining

The boring process involves carefully placing the machine’s head into the already drilled or cast hole. The device then starts to widen the hole by slowly scraping away portions of the inner wall. The boring tools are similar to those of lathes used in turning and milling machines.

Every boring machine contains the following parts.

●**Chuck:** The clamp that firmly holds the material in place during boring.

●**Workpiece**: The material you intend to bore a hole into using the boring machine.

●**Boring :** The cutting tool that removes (scrapes) portions of the holes, resulting in a more expansive and precise hole.

Types of Drilling Machines:

1 CNC Drilling Machine. ...
2 Drilling Machine. ...
3 Radial Drilling Machine. ...
4 Upright Drilling Machine. ...
5 Gang Drilling Machine. ...
6 Deep-Hole Drilling Machine. ...
7 Multiple-Spindle Drilling Machine. ...
8 Portable Drilling Machine.

Operations on a Drilling Machine:

Although drilling is the primary operation performed by this machine, a variety of similar operations are also done on holes using other tools. The following is a list of various drilling machine operations to create different types of holes.
Drilling

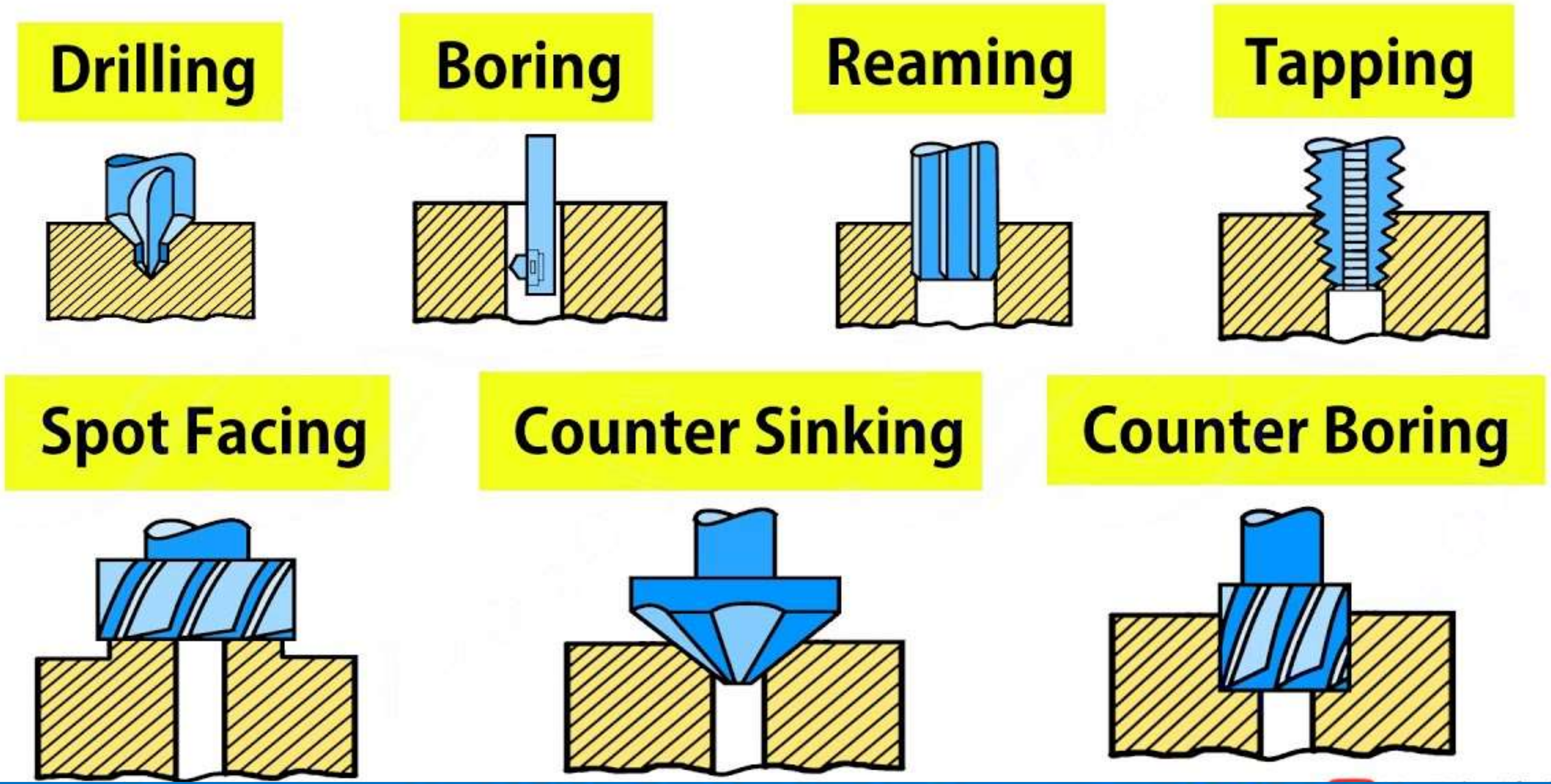
A cutting process that involves spinning a drill bit to create a circular hole in solid materials is known as drilling. The drill bit is typically a multi-point rotary cutting tool. The bit is pressed against the workpiece and rotated at speeds between several hundred and several thousand revolutions per minute.
This causes the cutting edge to press against the workpiece, removing chips

Types of Boring Machines

- Horizontal Boring Machine (HBM)
  1. Table type HBM
  2. Planer type HBM
  3. Floor Type HBM
  4. Multiple Spindle HBM
- Vertical Boring Machine (VBM)
  1. Single Column VBM
  2. Double Column VBM

Types of
Horizont
1. Table ty
2. Planer t
3. Floor Typ
4. Multiple
Vertical
1. Single C
2. Double C
Types of Boring Machines
Types of

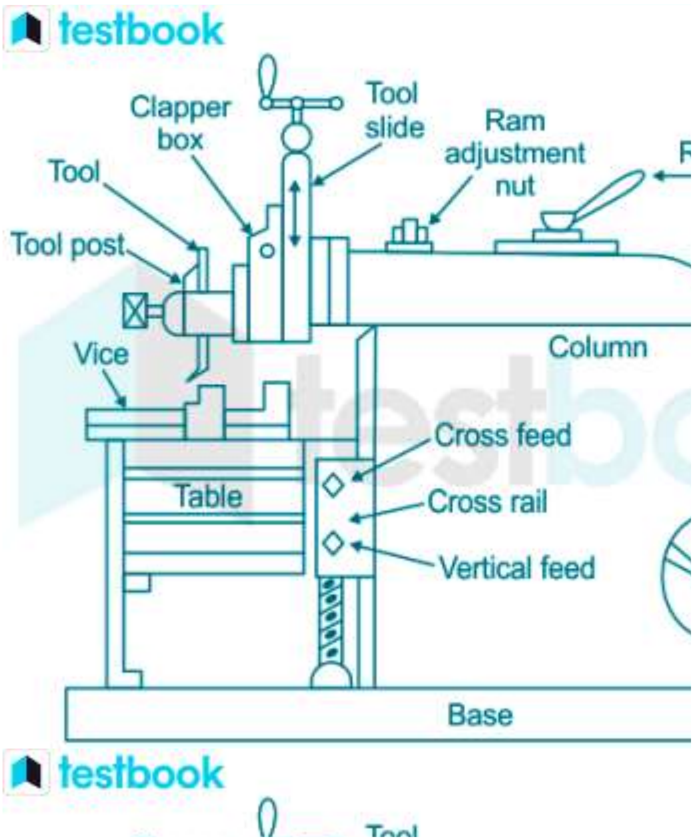
Drilling Operations



Application:

1 Boring machines are commonly used in the manufacturing industry for several applications, including machining of engine blocks, connecting rods, and cylinders in the automotive industry. Additionally,
2 they are also used in the production of gears, pumps, and other industrial components.
3 These machines are essential for precision engineering, and they help to ensure that the final product meets the required specifications,
4 operation of a boring machine involves the use of a cutting tool to remove material from the workpiece.
5 cutting tool is mounted on a spindle, which rotates at high speed, while the workpiece remains stationary. The machine may be manually operated, but more advanced models are computer**-controlled and can**

Parts of Shaping Machine:



Base:

The base of the shaper holds all of the weight of the machine tool, and it is bolted to the shop floor. It is generally made of cast iron. It absorbs vibrations and other forces imparted during shaping operation.

Column:

The column is also made of cast iron in a box shape. It is set on the base of the shaper. It has precisely machined guideways on top that allow the ram to move back and forth. For the cross rail to move, there are guideways on the front vertical face. The ram-driving mechanism is inside the column. The base holds the column in place.

Table:

The table is one of the crucial components of the device which is mounted on the saddle. The elevating screw and crossfeed rod can be

Vice

Clamp or vice is mounted on the table to hold the workpiece firmly while the shaping process is in progress.

Crossrail

This part is fixed to the vertical guideways of the column. By turning an elevating screw, which enables the cross rail to glide on the vertical face of the column, the table can be elevated or lowered to meet the varying sizes of the task.

Saddle

It is fixed to the Crossrail securely on the top of the table. The rotation of the crossfeed screw causes the crosswise movement of the saddle which moves the table in the same direction.

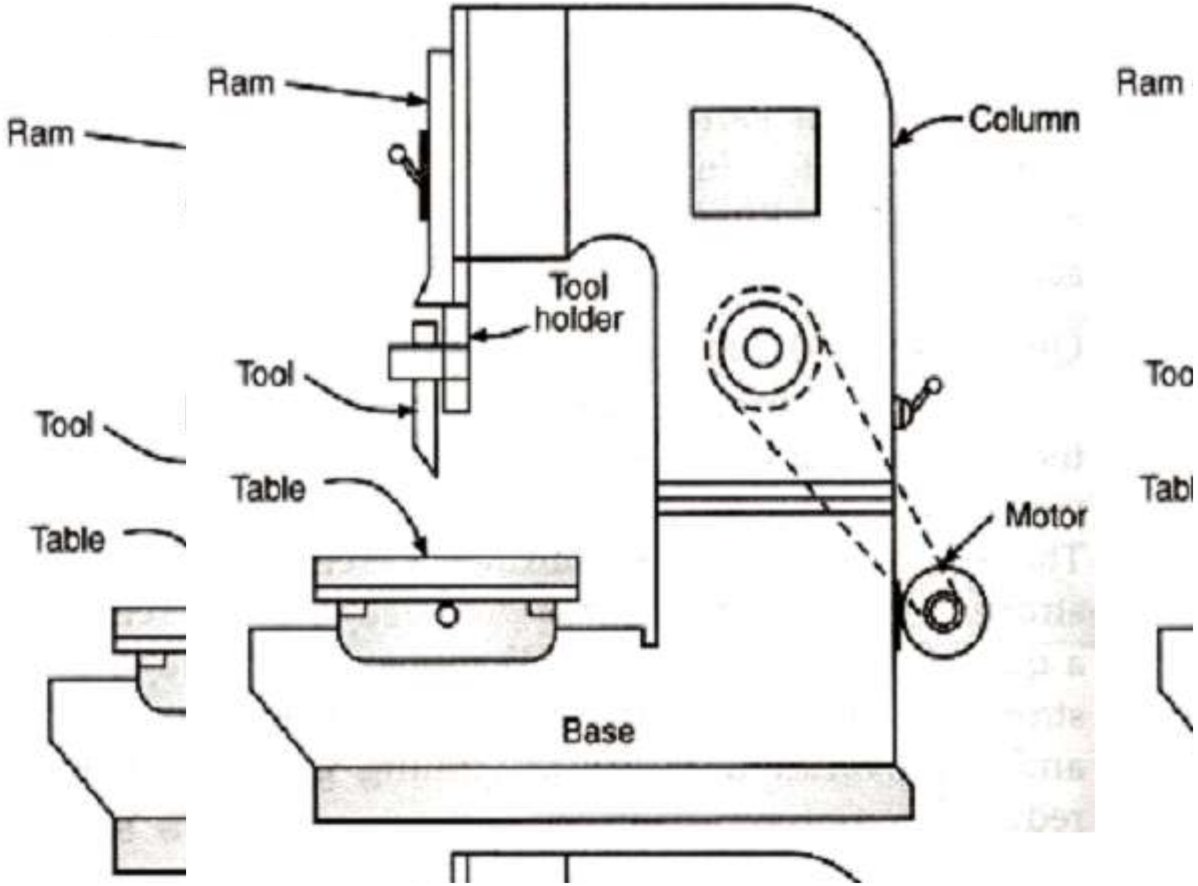
Ram:

It is a component in the shaping machine that reciprocates using a quick return motion mechanism on the guideways at the top of the column while holding the tool in place. It contains a screwed shaft to adjust the working position.

Tool Head:

With the down-feed screw handle, the tool head secures the cutting tool and allows for both vertical and rotational movement. A tool head of shaping machine assembly has a vertical slide is made up of a swivel base with graduated degrees.

principle of slotting machine :



Construction: The slotter can be considered as a vertical shaper and its main parts are:

1. Base, column and table

2. Ram and tool head assembly

3. Saddle and cross slide

4. Ram drive mechanism and feed mechanism.

The base of the slotting machine is rigidly built to take up all the cutting forces. The front face of the vertical column has guide ways for Tool the reciprocating ram.

The ram supports the tool head to which the tool is attached. The workpiece is mounted on the table which can be given longitudinal, cross and rotary feed motion.

The slotting machine is used for cutting grooves, keys and slotes of various shapes making regular and irregular surfaces both internal and external cutting internal and external gears and profi**les**

The slotter machine can be used on any type of work where vertical tool movement is considered essential and advantageous.
The different types of slotting machines are:

1. Punch slotter: a heavy duty rigid machine designed for removing large amount of metal from large forgings or castings

2. Tool room slotter: a heavy machine which is designed to operate at high speeds. This machine takes light cuts and gives accurate finishing.

3. Production slotter: a heavy duty slotter consisting of heavy cast base and heavy frame, and is generally made in two parts.

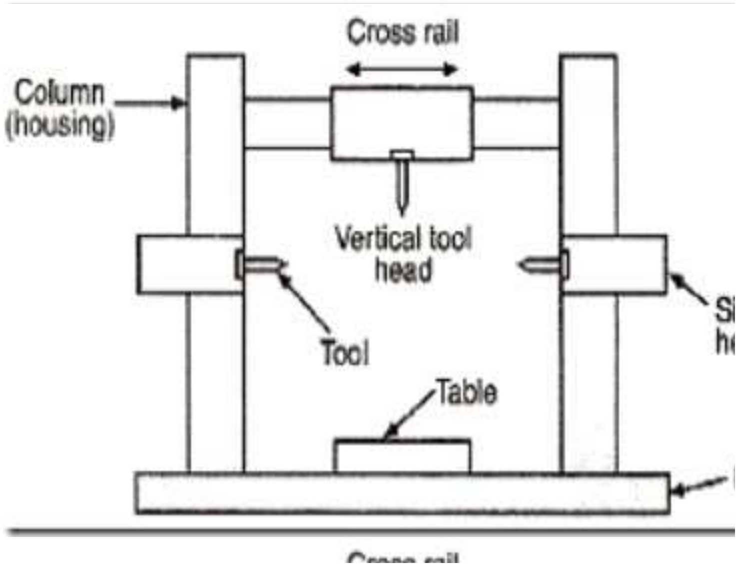
principles of working planning machine:

Operations of planer machine: The planer is used for

1. Planing flat horizontal, vertical and curved surface
2. Planing at an angle and machining dovetail
3. Planing slots and groove

<u>Construction</u>: The main parts of the double Housing Planer machine is Bed and table, Housings, Cross rail, , Tool heads, Driving and feed mechanism.

1 bed and table: The bed is a long heavy base and table made of cast iron. Its top surface is flat and machined accurately. The flat top surface has slots in which the workpiece can be securely clamped. The workpiece needs rigid fixing so that it does not shift out of its position. The standard clamping devices used on planer machine are: Heavy duty vice, T-holders and clamps, angle plate, planer jack, step blocks and stop. The table movement may be actuated by a variable speed drive through a rack and pinion arrangement, or a hydraulic system.


Cross rail
Column (housing)
Vertical tool head
Tool
Table

Cross rail: The cross rail is a horizontal member supported on the machined ways of the upright columns. Guide ways are provided on vertical face of each column and that enables up and vertical movement of the cross rail. The vertical movement of the cross rail allows to accommodate workpiece of different heights. Since the cross rail is supported at both the ends, this type of planer machine is rigid in construction.

Tool heads: Generally two tool heads are mounted in the horizontal cross rail and one on each of the vertical housing. Tool heads may be swiveled so that angular cuts can be made.

Driving and feed mechanism: The tool heads may be fed either by hand or by power in crosswise or vertical **direction. The motor drive is usually** at one side of the planer near the centre and drive mechanism is located under the table.

The size of the planer is specified by the maximum length of the stroke,

- Spindle Speed - N (rpm)
  - v = cutting speed
  - D_o = outer diameter

$$N = \frac{v}{\pi D_o}$$

- Feed Rate - f_r (mm/min -or- in/min)
  - f = feed per rev

$$f_r = N f$$

- Depth of Cut - d (mm/rev -or- in/rev)
  - D_o = outer diameter
  - D_f = final diameter

$$d = \frac{D_o - D_f}{2}$$

- Machining Time - T_m (min)
  - L = length of cut

$$T_m = \frac{L}{f_r}$$

- Mat'l Removal Rate - MRR (mm^3/min -or- in^3/min)

If $$K = \frac{\text{Time for return stroke}}{\text{Time forward stroke}}$$

Then cutting speed is given by

$$S = \frac{L(1+K)}{1{,}000} \times N \text{ m/min}$$

$$\text{Now time taken by cutting stroke} = \frac{L}{S \times 1{,}000}$$

$$\text{Now time taken by return stroke} = \frac{L}{S \times 1{,}000} \times K$$

The total time for one cut (one cutting stroke and one return stroke)

$$T = \frac{L}{S \times 1{,}000} + \frac{LK}{S \times 1{,}000} = \frac{L(1+K)}{1{,}000 \times S}$$

Now if W = Width of job in mm

f = feed per stroke

$$\text{Then number of strokes required to complete one pass on full width} = \frac{W}{f}$$

$$\text{Total time for completing one cut} = \frac{L(1+K)}{1{,}000\, S} \times \frac{W}{f}$$

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Then cutting speed is given by

$$S = \frac{L(1+K)}{1{,}000} \times N \text{ m/min}$$

Machining Time

Let

L = length of ram stroke, mm
B = breadth of job, mm
f = feed in mm/double stroke
m = ratio of return time to cutting time
v = cutting speed, m/min

We know from Eqn. (6.85) that

Time taken in completing one double stroke = $\frac{L}{1000 \cdot v}(1+m)$

7 Total number of double strokes required to complete the work = $\frac{B}{f}$

Hence, time taken to complete machining = $\frac{L \cdot B \cdot (1+m)}{1000 \cdot f \cdot v}$ 8

Metal removal rate (MRR)

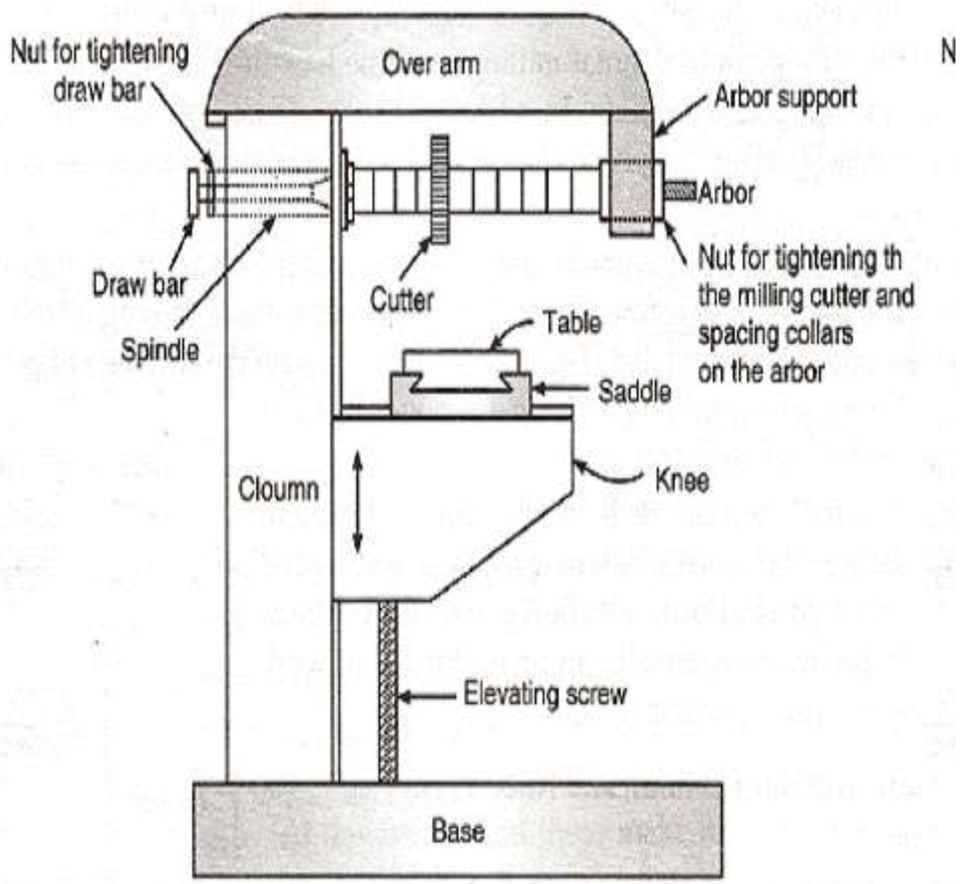
$$\text{MRR} = f \cdot d \cdot n \cdot L(1+m), \text{ mm}^3/\text{min} \quad 9$$

Machining Time

Principle and Working of MILLING MACHINE:

Working Principle:

The workpiece is holding on the worktable of the machine. The table movement controls the feed of workpiece against the rotating cutter. The cutter is mounted on a spindle or arbor and revolves at high speed. Except for rotation the cutter has no other motion. As the workpiece advances, the cutter teeth remove the metal from the surface of workpiece and the desired shape is produced.


Nut for tightening
draw bar
Over arm
Arbor support
Arbor
Draw bar
Spindle
Cutter
Nut for tightening th
the milling cutter and
spacing collars
on the arbor
Table
Saddle
Cloumn
Knee
Elevating screw
Base

UNIT 3

MILLING MACHINES

INTRODUCTION

A milling machine removes material from a work piece by rotating a cutting tool (cutter) and moving it into the work piece. Milling machines, either vertical or horizontal, are usually used to machine flat and irregularly shaped surfaces and can be used to drill, bore, and cut gears, threads, and slots.

1. **Base**: It gives support and rigidity to the machine and also acts as a reservoir for the cutting fluids.
2. **Column**: The column is the main supporting frame mounted vertically on the base. The column is box shaped, heavily ribbed inside and houses all the driving mechanisms for the spindle and table feed.
3. **Knee**: The knee is a rigid casting mounted on the front face of the column. The knee moves vertically along the guide ways and this movement enables to adjust the distance between the cutter and the job mounted on the table. The adjustment is obtained manually or automatically by operating the elevating screw provided below the knee.
4. **Saddle**: The saddle rests on the knee and constitutes the intermediate part between the knee and the table. The saddle moves transversely, i.e., crosswise (in or out) on guide

5. **Table**: The table rests on guide ways in the saddle and provides support to the work. The table is made of cast iron, its top surface is accurately machined and carriers T-slots which accommodate the clamping bolt for fixing the work. The worktable and hence the job fitted on it is given motions

6. **Overar**m: The Overarm is mounted at the top of the column and is guided in perfect alignment by the machined surfaces. The Overarm is the support for the arbor.

7. **Arbor support**: The arbor support is fitted to the Overarm and can be clamped at any location on the Overarm. Its function is to align and support various arbors. The arbor is a machined shaft that holds and drives the cutters.

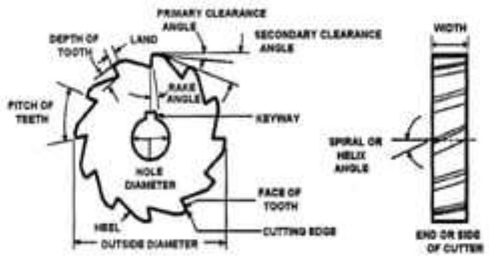
8. Elevating screw: The upward and downward movement to the knee and the table is given by the elevating screw that is operated by hand or an automatic feed.

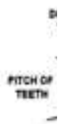
types of milling machine:

1 Vertical milling machine.
2 Horizontal milling machine.
3 Universal milling machine.
4 Dro milling machine.
5 CNC milling machine.
6 Tracer Controlled Milling Machine.
7 Omniversal milling machine.

Geometry of Plane Milling Cutter

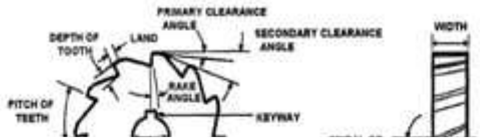
Geo





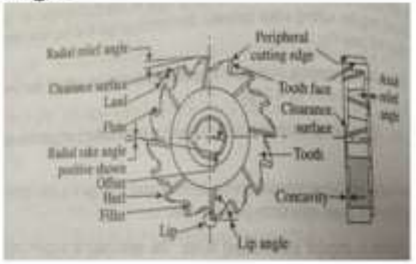
Geometry of Plane Milling Cutter

Geo



Geometry of Plane Milling Cutter

- Radial Rake Angle
- Radial Relief Angle
- Land
- Flute
- Heel
- Fillet
- Lip angle



Ge

- Rad
- Rad
- Lan
- Flut
- Hee
- Fille
- Lip

INDEXING METHODS:

Indexing in milling machines is a fundamental technique that plays a crucial role in precision machining. This process involves rotating the workpiece or the cutter to a specific angular position, allowing for the precise cutting of slots, grooves, or features at desired intervals. It is an indispensable tool for creating complex geometries and achieving accuracy in milling operations. This blog will uncover all about Indexing in milling

Types of Indexing Methods:

Different methods of indexing are utilised in various machining operations. These methods include:

1. Index Plate:

An index plate is a circular metal plate featuring multiple concentric circles of evenly spaced holes. A crank with an index pin can be positioned in any of these holes, facilitating precise indexing for various applications. Commonly used plates include Brown and Sharpe type and Cincinnati type.

For Brown and Sharpe type plates, there are three plates, each featuring six circles with holes arranged as follows:

Plate 1: 15, 16, 17, 18, 19, 20 holes

Plate 2: 21, 23, 27, 29, 31, 33 holes
Plate 3: 37, 39, 41, 43, 47, 49 holes
In the case of Cincinnati type plates, a single plate is used, with holes evenly distributed on both sides:
First side: 24, 25, 28, 30, 34, 37, 38, 39, 41, 42, 43 holes
Second side: 46, 47, 49, 51, 53, 54, 57, 58, 59, 62, 66 holes
Formula =(linear pitch of the job or workpiece X 40 Indexing movement)/(Lead of the table lead screw)

2. Simple Indexing: Simple indexing is achieved using a plain indexing head or universal dividing head on a milling machine. It employs a worm, crank, index head, and worm wheel to create precise divisions.

The indexing process utilises several components, including a worm, crank, index head, and worm wheel. Typically, the worm wheel is equipped with 40 teeth, while the worm itself is single-threaded. This configuration ensures that as the crank completes one full revolution, the work wheel rotates by 1/40th of a complete revolution.

Moreover, the worm wheel turns by 2/40th (or 1/20) of a revolution. Consequently, for every single revolution of the workpiece, the crank needs to complete 40 revolutions. Additionally, the holes in the index plate play a crucial role in further subdividing the rotation of the workpiece, enhancing the precision of the indexing process.

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3. Compound Indexing:

Compound indexing is used when complex divisions are required. It combines two simple indexing movements to achieve the desired result.
Number of Turns = (N1 * N2) / H
Where:
"N1" represents the number of divisions on the first index plate.
"N2" represents the number of divisions on the second index plate.
"H" represents the total number of divisions required for the desired compound indexing.

4. Differential Indexing:

In cases where the divisions needed cannot be obtained through simple indexing, a differential indexing approach is employed. It involves a complex arrangement of gears to achieve the required indexing.

The formula for calculating the number of turns required for differential indexing on a milling machine is:

Number of Turns = (N1 * N2 - 1) / H

Where:

"N1" represents the number of divisions on the first index plate.

"N2" represents the number of divisions on the second index plate.

"H" represents the total number of divisions required for the desired

5. Direct Indexing:

Direct indexing utilises index heads that allow for faster indexing by disconnecting the worm from the worm wheel. A knob controls the index head, facilitating quick and efficient indexing.
The formula for calculating the number of turns required for direct indexing on a milling machine is:
Number of Turns = (N1 / H)
Where:
"N1" represents the number of divisions on the index plate.
"H" represents the total number of divisions required for the desired direct indexing.

6. Plain Indexing:

plain indexing relies on principles like dividing a full revolution into equal parts. For example, to mill eight equally spaced teeth on a gear, the crank is turned five times after each cut to achieve the desired spacing.

The formula for calculating the number of turns required for plain indexing on a milling machine is:

Number of Turns = (N / H)

Where:

"N" represents the number of divisions on the index plate.

"H" represents the total number of divisions required for the desired plain indexing.

7. Indexing Operation:

Indexing operations follow specific rules to determine the number of turns required to obtain the desired divisions. For example, to cut a gear with 42 teeth, you divide 40 by 42, resulting in 20/21 turns, which corresponds to indexing 20 spaces on a 21-hole circle.
These indexing methods are essential in machining operations for achieving precise and consistent results.

Grinding Machine

- ***Grinding*** is a metal removal process by the action of a rotating ***abrasive wheel.***
- *An **abrasive*** is a material whose particles are extremely hard and can be used to machine materials such as hardened steel, glass, carbides, ceramics, etc.
- Grinding operation may be used for removing a thick layer (about 0.5 mm) of material in general class of work.
- Usually grinding is used for finishing & polishing of parts produced by other machining process.

- ***Grinding***
action of a
- *An **abras***
extremely
materials
ceramics,
- Grinding
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Basic Grinding Theory:

provides an overview of the general process of grinding . Grinding occurs at the point of contact between an abrasive wheel and a workpiece. Like any other cutting process, grinding removes material in the form of chips. In order for a wheel to grind properly, its abrasive grains must wear and self-sharpen at a consistent rate. Otherwise, wheel problems such as loading and glazing may occur. Truing and dressing wheels and applying grinding fluids can fix or prevent these issues.

An understanding of grinding wheels and

An understanding of grinding wheels and processes allows operators to perform grinding operations effectively and recognize and address any grinding wheel problems that may occur. This understanding and recognition will improve the accuracy, precision, and overall success of grinding operations, reducing scrap

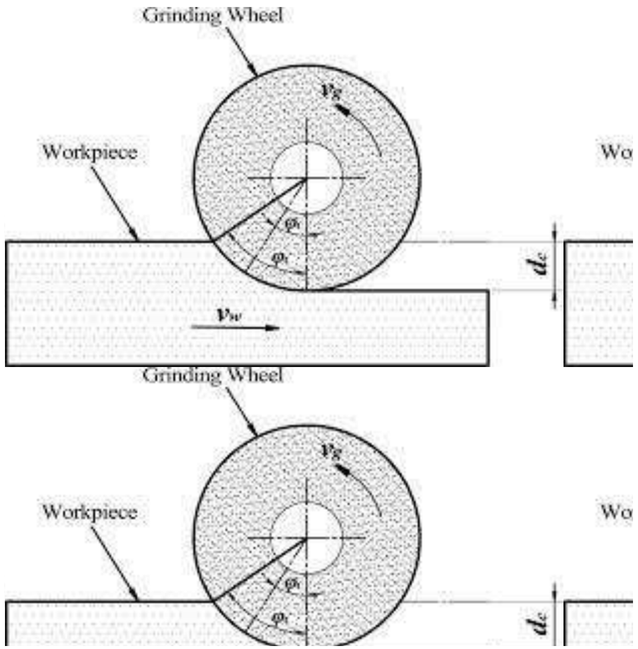

TYPES OF ABRASIVES
Natural Abrasives
• Diamond
• Corundum
• Garnet
• Quartz
• Softer Materials Found within the Earth
Artificial Abrasives
• Synthetic Diamond
• Silicon Carbide
• Aluminum Oxide
• Boron Carbide
• Various Aluminas
• Carborundum

GRINDING WHEELS

- Grinding wheel consists of hard abrasive grains called grits, which perform the cutting or material removal, held in the weak bonding matrix.
- A grinding wheel commonly identified by the type of the abrasive material used.
- The conventional wheels include aluminium oxide and silicon carbide wheels while diamond and CBN (cubic boron nitride) wheels fall in the category of superabrasive wheel.

Selection of grinding wheels

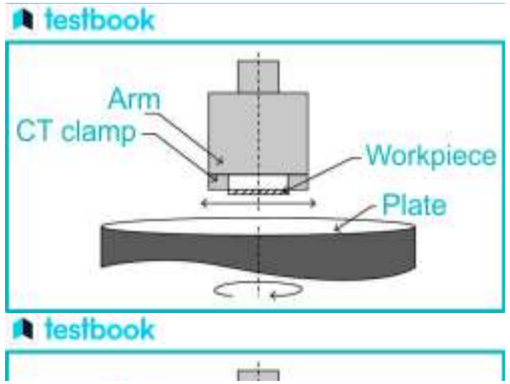
- Selection of grinding wheel means selection of composition of the grinding wheel and this depends upon the following factors:
  1) Physical and chemical characteristics of the worl material
  2) Grinding conditions
  3) Type of grinding (stock removal grinding or form finish grinding)


Grinding Wheel
Workpiece
Grinding Wheel
Workpiece


What is Lapping?
Lapping is a mechanical precision finishing operation done to achieve **high dimensional accuracy**
CONDITIONING RINGS
LAP PLATE
WORKPIECE
ABRASIVE
Diagram of the lapping process in action

The lapping process is a precision machining technique that is pivotal in achieving unparalleled levels of flatness, surface finish, and dimensional accuracy in various engineering and manufacturing applications. This unique abrasive machining method involves using a highly abrasive slurry or paste, along with a rotating lap or workpiece, to remove material systematically from the surface of a workpiece. This process is renowned for producing exceptionally flat and smooth surfaces, making it indispensable in optics, aerospace, automotive, and semiconductor

Principle of Lapping machine:



Principle of Lapping machines:

1 The fundamental principle underlying the lapping process encompasses three key components: a workpiece, a lapping plate, and abrasive particles. In this process, abrasive particles are distributed onto the lapping plate, and
2 the workpiece is then moved across it through rubbing action.
As a result of the applied force during the relative motion between the plate and the workpiece,
3 these abrasive particles meticulously eliminate minuscule material portions from the workpiece.
4 The primary effect of this abrasive action is to diminish or flatten the microscopic peaks and valleys that exist on the surface of the workpiece.
5 It's worth noting that lapped surfaces may exhibit faint "micro-scratches," which are typically less than 0.000001 inches deep and cannot be detected using

Lapping machines features:

Features include your choice of Lap plate configuration and movable ring positioning arms or reversible ring drive for table flatness control. These systems are complete with manual controls for the cycle time, slurry delivery and speed controls.

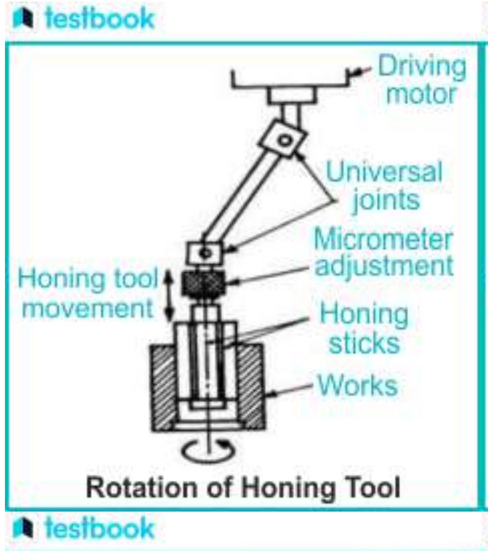
Honing machine definition:

Honing is an abrasive machining process that is a combination of grinding and drilling operation. It uses an Abrasive grinding tool to accurately machine the given workpiece. Honing process improves the surface quality of the workpiece as well as provides dimensional accuracy to the part being machined.

A moving Abrasive stone is made to come in contact with the part to be machined hence producing an accurate finished job. Honing is used in industries where accuracy and aesthetics both are considered important. Generally, a honing process uses CNC to direct the tool on the workpiece. A honing process is mostly used to finish the boreholes in a workpiece.

Working Principle of Honing machines:

The basic principle involved in the honing process is the cutting action performed by the Abrasive particles when a linear, as well as a tangential force, is applied. The friction generated by the contact of Abrasive stones and the workpiece results in the material removal from the workpiece.



Rotation of Honing Tool

1 honing serves as a micro-finishing process utilised to rectify hole geometry within components. This abrading technique focuses on enhancing round holes, employing specially crafted bonded abrasive stones known as hones.

2 Its primary purpose lies in correcting irregularities such as out-of-roundness, taper, tool marks, and axial distortion.

3 Abrasives commonly employed in honing encompass Silicon carbide, aluminium oxide, diamond, or cubic boron nitride.

4 When honing is carried out manually, the honing tool rotates while the w workpiece is reciprocated over the tool.

5 the stones extend beyond the workpiece's surface at the end of each stroke. In precision honing,

6 the workpiece is typically secured in a fixture, and the tool undergoes a slow reciprocating motion while it rotates, resulting in a complex motion that combines rotation with oscillatory axial movement.

7 These combined motions create a distinctive cross-hatch pattern on the workpiece surface. Honing stones may be affixed within the honing head by cementing them into metal shells,

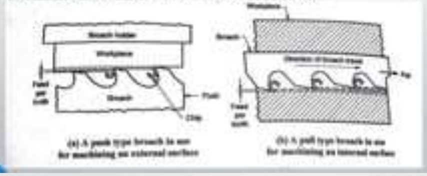
8 which are clamped into the holder or directly cemented into holders. The inclusion of coolants in this process is essential to flush away small chips and maintain uniform

What is Broaching?

- Broaching is a machining operation in which a tool used is called as **broach** having series of cutting teeth.
- In this operation broach is either **Pulled** or **Pushed** with the help of broaching machine on the workpiece surface.
- Parts that is produced by the broaching have **good surface finish** and **dimensional accuracy**.

Principle of Broaching

- When the broach is fed in a straight line, metal is cut in **several successive layer** with the help of broach.
- The thickness of each layer is same and called as **feed per tooth** and sum of the thickness of all the layers is called as **depth of cut**.



Principle of Broaching

- When the broach is fed in a straight line, metal is cut in **several successive layer** with the help of broach.
- The thickness of each layer is same and called as **feed per tooth** and sum of

FACTORS TO BE CONSIDE
MACHINE TIME CALCUI

- Set up time
- Operation time
- Tear down time
- Personal allowance
- Fatigue allowance
- Checking allowance
- Miscellaneous allowance

IMPORTANCE OF MACHINING TIME CALCULATION

- To find the manufacturing cost of a particular job the calculation of machining time is important, this requires one or more machining operations.
- After determining the total time for machining, and knowing the machining cost per unit time, the total cost of machining can be worked out.
- Machining time is calculated by applying certain basic formulae, tables of variables and constants.

IMPORTANCE OF MACHINING TIME

- The basic formula used is

$$\text{Machining time} = \frac{\text{Travel of the tool necessary}}{\text{Feed} \times \text{rpm}}$$

TRAVEL OF THE TOOL

- This is determined from the dimensions in the actual drawing of the part to be manufactured.
- The necessary allowances for the tool approach and over-run for clearing the tool off the job are taken into account with the actual length of the work, to find the travel of the tool.

If Actual length of the work = l

Amount of tool approach = A

Amount of tool over run = O

Then, travel of the tool $L = l + A + O$

- The basic formula used is

$$\text{Machining time} = \frac{\text{Travel of the tool necessary}}{\text{Feed} \times \text{rpm}}$$

RPM

- It represents the number of revolutions of the m/c spindle in one minute.
- Thus it is the number of revolutions per minute of the job or of tool.

CUTTING SPEED

- The cutting speed can be defined as the relative surface speed between the tool and the job.
- It is expressed in meters per minute (mpm)
- For example if a job of diameter D mm is revolving at a speed of N rpm

$$\text{Cutting speed } V = \frac{\pi DN}{1000} \text{ m/min}$$

UNIT 4

LIMITS

INTRODUCTION:

In mathematics, a limit is the value that a function (or sequence) approaches as the input (or index) approaches some value. Limits are essential to calculus and mathematical analysis, and are used to define continuity, derivatives, and integrals.

Definition: Limit

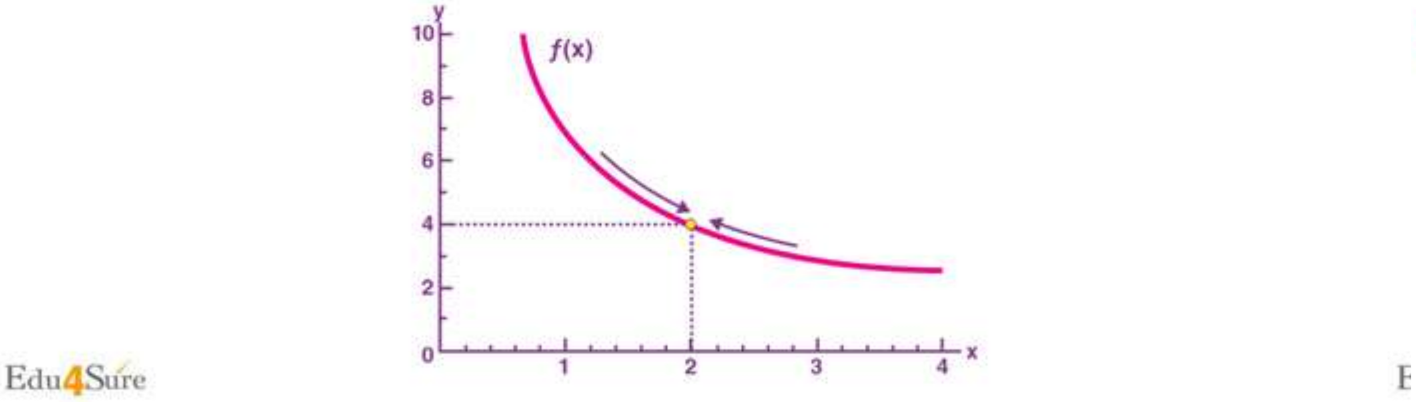
Let c and L be real numbers. The function ***f* has limit *L* as *x* approaches *c*** if, given any positive number ε, there is a positive number δ such that for all x,

$$0 < |x - c| < \delta \Rightarrow |f(x) - L| < \varepsilon$$

We write $$\lim_{x \to c} f(x) = L$$

which is read, "the limit of f of x as x approaches c equals L."

What Is Limit Calculus? Its Types & Techniques To Solve



Limit Calculus is the branch of calculus that approximates and predicts the value of the different functions and certain quantities to a certain point. Basically in mathematics, we use it to find the numerical value of the function at a certain point. So, in mathematics, we use it to define definite integrals, provide the first definition of derivatives, and determine the continuity of the functions.

Types of limits:

In this section, we discuss the types of limits. There are two type of limits given below.

1.One-sided limit (left & right-hand limit)

2.Two-sided limit

1) One-sided limit

1) One-sided limit:

This limit function is only defined at an open interval. So, we can check the limit by both ends from the left side of the interval and also from the right side of the interval. Also, it is further categorized into two types given below.

1. Left-hand limit
2. Right-hand limit

a) Left-hand limit:

In this limit, we move from the left side of the interval and the interval is defined as a ϵ [a + ε, a – ε]. g(X) is defined on the interval as given below,

$$\lim_{X \to a^-} g(X) = L$$

It is read as the left-hand limit of g(X) as "X" approaches "a" and

"L" is the result of the limit. This limit moves from the negative direction of the real line.

b) Right-hand limit:

In this limit, we move from the right side of the interval and the interval defined as a ϵ [a + ε, a − ε]. g(X) is defined on the interval as given below,

$\lim_{X\to a+} g(X) = L$

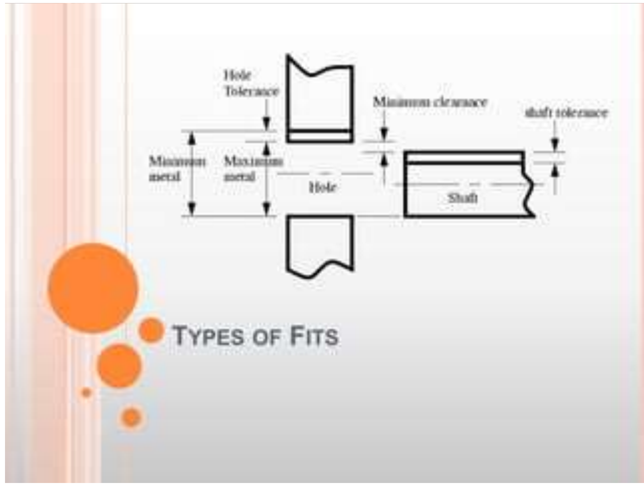
It is read as the right-hand limit of g(X) as "X" approaches "a" and "a" is the point where the limit find. "L" is the result of the limit. This limit moves from the positive direction of the real line.

2) Two-sided limit:

If the both-sided limit exists (left & right-hand limit) and the same is called the two-sided limit exists. In this limit, we check both side limits from the left hand as well as from the right hand and compare the results must be equal.

WHAT ARE FITS?

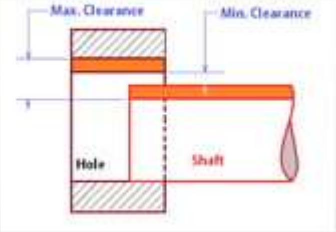
- Fit is defined as the degree of freedom of tightness between the mating parts in an assembly. Fit obtaining parts are either movable joint or fixed joint.


Hole
Tolerance
Minimum clearance
shaft tolerance
Minimum
metal
Maximum
metal
Hole
Shaft
TYPES OF FITS

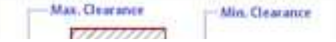
CLEARANCE FIT

- This means there is a gap between the two mating parts.
- Clearance fit is arises at the Diameter of the shaft is smaller then the hole.
- The minimum diameter of hole is grater then large diameter of the shaft.
- Clearance value is positive when in this type of fit

Clearance fit



Clearance fit



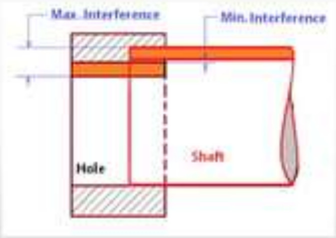
TRANSITION FIT

- Transition fit is neither loose nor tight as like clearance fit and interference fit.

- The transition fit is two types they are.
  - Wringing Fit
  - Push fit

TRANSITION F
Transition fit is
clearance fit a
The transition
Wringing Fit
Push fit

INTERFERENCE FIT



Interference fit

- The hole and shaft are intended to be attached permanently
- The interference fits are classified into 3 types they are.
  - Force fit
  - Tight fit
  - Heavy Force and shrink fit

INTERFERENCE FIT

- **Force fit:**
  - This type of fits are employed for mating parts. This are not disassembled during their service life.
    - Example of force fit: Gears on the shafts of a concrete mixer, Forging machine.
- **Tight fit:**
  - This type of fits are provide less amount of interference than force fits.
  - Tight fits are employed for mating parts, which are maybe replaced while overhauling the machine
    - Examples of Tight fit: Stepped pulleys on the drive shaft of a conveyors, cylindrical grinding machine.

INTERFERENCE FIT

- **Heavy Force and shrink fit:**
  - Heavy force and shrink fit type of fit there is negative allowances.
  - For assembling the parts here more force is required.

TOLERANCES:

INTRODUCTION-

- Factors that determine the performance of a manufactured product, other than mechanical and physical properties, include
  - Dimensions - linear or angular sizes of a component specified on the part drawing
  - Tolerances - allowable variations from the specified part dimensions that are permitted in manufacturing.
- A *dimension* is "a numerical value expressed in appropriate units of measure and indicated on a drawing and in other documents along with lines, symbols, and notes to define the size or geometric characteristic, or both, of a part or part feature"
- Dimensions on part drawings represent nominal or basic sizes of the part and its features.

- A *tolerance* is "the total amount by which a specific dimension is permitted to vary. The tolerance is the difference between the maximum and minimum limits"
- Variations occur in any manufacturing process, which are manifested as variations in part size
- Tolerances are used to define the limits of the allowed variation.

- Dimensioning can be divided into three categories:
  - general dimensioning,
  - geometric dimensioning, and
  - surface texture.

TYPES OF TOLERANCES

A Dimensional tolerance is the total amount a specific dimension is permitted to vary, which is the difference between maximum and minimum permitted limits of size.

A Geometric tolerance is the maximum or minimum variation from true geometric form or position that may be permitted in manufacture.

Geometric tolerance should be employed only for those requirements of a part critical to its functioning or interchangeability.

Bilateral Tolerance

Variation is permitted in both positive and negative directions from the nominal dimension

- Possible for a bilateral tolerance to be unbalanced; for example, 2.500 +0.010, -0.005

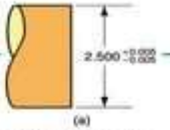


Fig: Ways to specify tolerance limits for a nominal dimension of 2.500

Unilateral Tolerance

Variation from the specified dimension is permitted in only one direction

- Either positive or negative, but not both

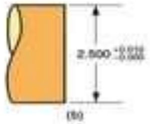
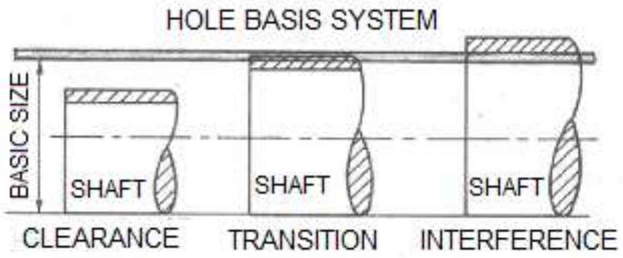


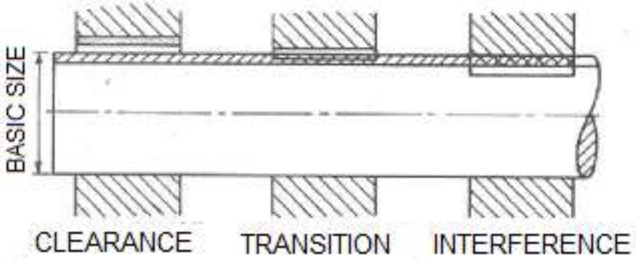
Fig: Ways to specify

HOLE AND SHAFT BASIS SYSTEM



HOLE BASED SYSTEM

Size of the Hole is kept constant, Shaft size is varied to get different fits



SHAFT BASED SYSTEM

Size of the Shaft is kept constant, Hole size is varied to get different fits

HOLE AND SHAFT BASIS SYSTEM

Interchangeability

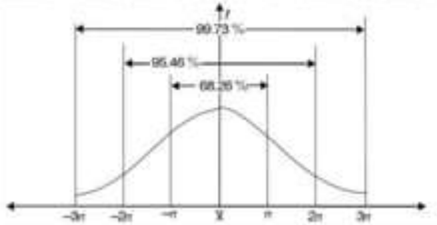
Definition Situation where two or more items are so similar in functional and physical characteristics that they are considered equivalent in performance and durability. Each is capable of replacing the other without causing a need for alteration or adjustment to fulfill the same requirement.

- Interchangeability of parts are achieved by combining a number of **innovations** and **improvements** in machining operations so that we will able produce **components** with **accuracy**.

- Modern machine tools like numerical control (NC) which evolved into CNC. Jigs and fixtures.

- Gauges to check the accuracy of the finished parts. These helps in manufacturing the components within its specified limits.

- If a plot is drawn of the actual dimensions of the similar components produced by a well-controlled machine. it is found to follow Normal distribution.



σ= Standard deviation

$\bar{X}$ =mean Σ X/N , f=frequency

- Example we have **100 parts** each with a hole and **100 shafts** which have to fit into these holes.
- If we have interchangeability then we can make any one of the **100 shaft** & fit it into any hole & be sure that the required fit can be obtained.

- **Any M6 bolt will fit to any M6 nut randomly selected.**

Selective assembly

- The discussion so far has been in connection with full interchangeability or random assembly in which any component assembles with any other component.

- Often special cases of accuracy and uniformity arises which might not be satisfied by certain of the fits given under a fully interchangeable system.

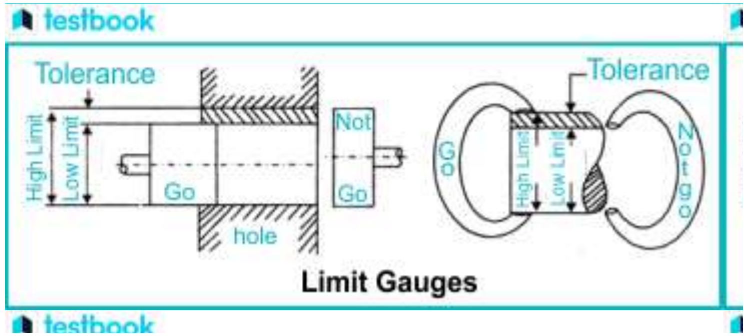
- For selective assembly, components are measured and **sorted into groups by dimension**, prior to the assembly process. This is done for both mating parts.

- Consider a bearing assembly
- Hole with $25^{-0.02}_{+0.02}$, Shaft $25^{-0.10}_{-0.14}$ Clearance should be 0.14mm
- Randomly if we take $25^{-0.02}$ and $25^{-0.10}$ clearance will be 0.08mm
- Hole and Shaft pairing respctively which gives 0.14mm clearance

  24.97 and 24.83, 25.0 and 24.86, 25.02 and 24.88

Limit Gauges:

Limit gauging is an inspection method employing specialised rigid gauges devoid of scales designed to assess the dimensions of manufactured components. These gauges do not provide actual dimension values; instead, they serve to ascertain whether a component falls within predetermined tolerance limits. Unlike traditional measuring instruments, limit gauges solely determine whether a part is within or outside the specified tolerance zone without quantifying dimension values or indicating the magnitude of any errors in the component.



Limit Gauges

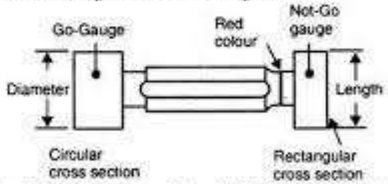
Working Principle of Limit Gauges

The working principle of limit gauges is straightforward: they are precision tools designed to check if a manufactured part's dimensions fall within specified limits. Limit gauges consist of "go" and "no-go" ends. If the "go" end fits the part within tolerance, and the "no-go" end does not, the part is considered acceptable. Conversely, the part is rejected if the "no-go" end fits. This binary assessment ensures parts meet quality standards without providing actual dimension values.

Taylor's Principle

Statement 2: - The "Go" gauge should always be so designed that it will cover as many dimensions as possible in a single operation, whereas the "NOT-GO" gauge will cover only one dimension.

Means a Go plug gauge should have a full circular section and be of full length of the hole being checked as in shown figure

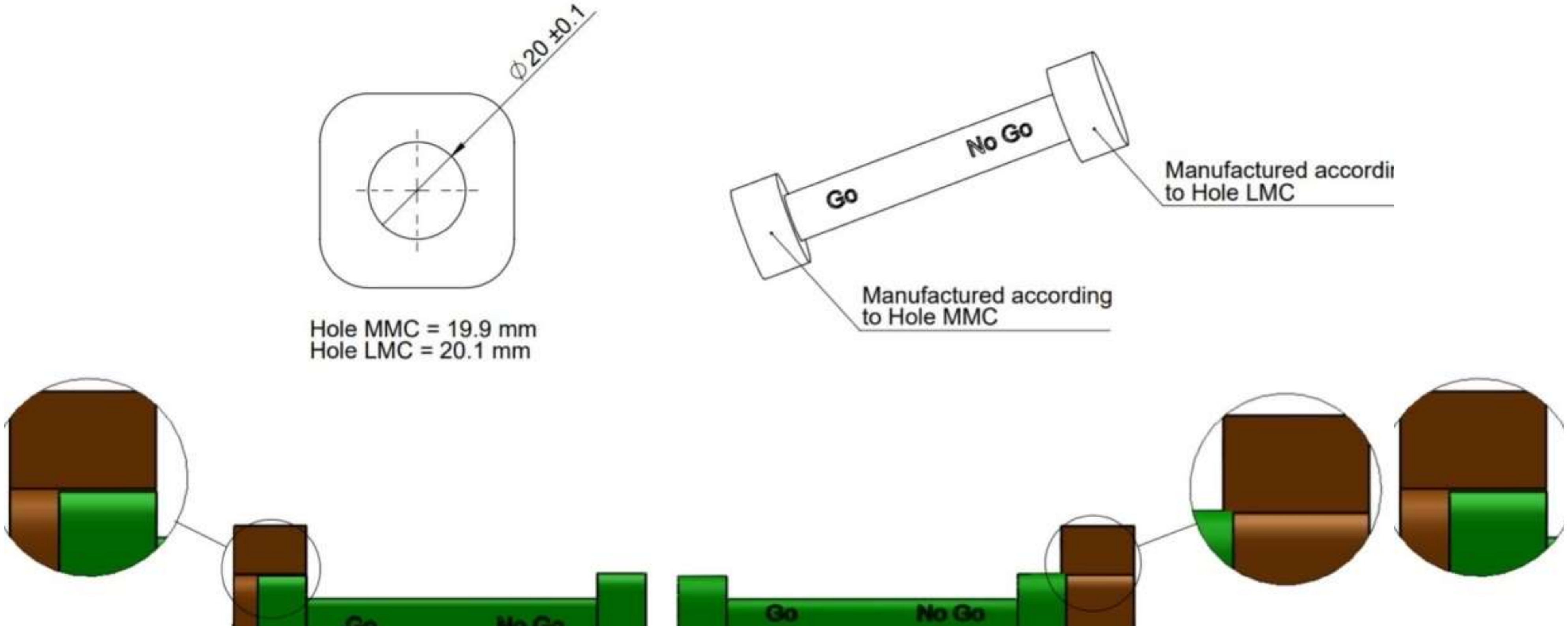


Go and Not-Go gauges for hole (Taylor's principle).

GAUGE DESIGN

- To a greater or lesser extent, every gauge is a copy of the part which mates with the part for which the gauge is designed.
- If a gauge is designed as an exact copy of the opposed part in so far as the dimension to be checked is concerned, it is called a ***'Standard Gauge'***.
- In design of a gauge, ***simplicity*** should be the main aim as simple gauges can take measurements continuously and accurately.

gO gauges are designed to check the maximum metal conditions i.e. Minimum hole limit and Maximum shaft limit. GO gauges should check as many related dimensions (form, size, location/positions) as possible. NO-GO gauges are designed to check the minimum metal conditions i.e. Maximum hole limit and Minimum shaft limit.

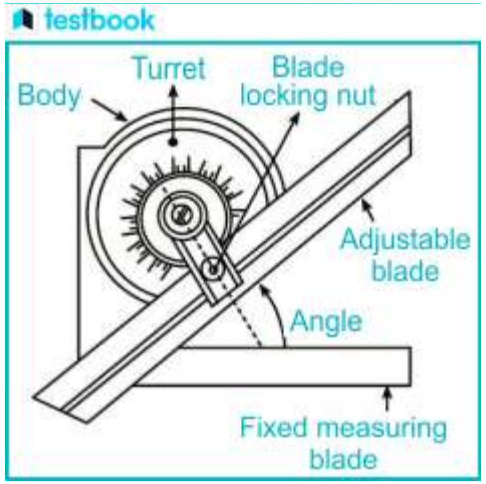


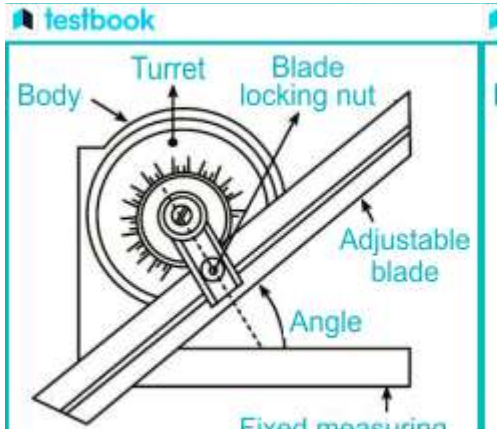
definition

A bevel protractor is a precision measuring instrument widely used in engineering, woodworking, and metalworking to accurately measure and set angles. This versatile tool is essential for tasks requiring precise angle measurements, such as the layout and machining of components, the alignment of machine tools, and the creation of intricate geometric shapes

Bevel Protractor?

A bevel protractor is a versatile measuring tool used to accurately determine angles, often in the realms of metalworking and woodworking. It features a pivoting arm with a graduated dial, allowing for precise angle measurements, making it indispensable in precision engineering and layout work.




testbook
Turret
Blade
locking nut
Body
Adjustable
blade
Angle

Working of Bevel Protractor

To begin the angle measurement process with a bevel protractor, start by positioning the workpiece between the blade and the stock of the instrument. Ensure that one side of the surface being measured aligns with the blade while the other sides make contact with the stock.

Once the workpiece is appropriately aligned with the blade and the blade itself is correctly positioned on the workpiece, secure the blade in place using a locking **screw designed for this purpose. Subsequently, when the surface**

THE SINE BAR

A sine bar is used in conjunction with slip gauge blocks for precise angular measurement. A sine bar is used either to measure an angle very accurately or face locate any work to a given angle. Sine bars are made from a high chromium corrosion resistant steel, and is hardened, precision ground, and stabilized.

Figure 1. The Sine Bar

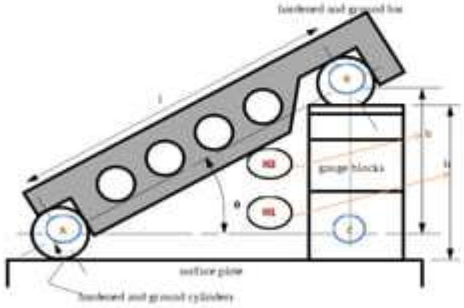
Two cylinders of equal diameter are placed at the ends of the bar. The axes of these two cylinders are mutually parallel to each other, and are also parallel to, and at equal distance from, the upper surface of the sine bar. Accuracy up to 0.01mm/m of length of the sine bar can be obtained.

A sine bar is generally used with slip gauge blocks. The sine bar forms the hypotenuse of a right triangle, while the slip gauge blocks form the opposite side. The height of the slip gauge block is found by multiplying the sine of the desired angle by the length of the sine bar: $\mathbf{H = L * \sin(\theta)}$.

For example, to find the gauge block height for a **13°** angle with a **5.000"** sine bar, multiply the **sin(13°)** by **5.000"**: **H = 5.000" * sin(13°)**. Slip gauge blocks stacked to a height of **1.124"** would then be used elevate the sine bar to the desired angle of **13°**.

SINE BAR PRINCIPLES

- The application of trigonometry applies to sine bar usage.
- A surface plate, sine bar, and slip gauges are used for the precise formation of an angle.
- It is possible to set up any angle **θ** by using the standard length of side **AB**, and calculating the height of side **BC** using **BC = AB * sin(θ)**.
- The angle **θ** is given by **θ = asin(BC/AB)**.
- Figure 1 shows a typical sine bar set up on a surface plate with slip gauge blocks of the required height **BC** to form a desired angle **θ**.



l = distance between centres of ground cylinders (typically 5" or 10")
h = height of the gauge blocks
θ = the angle of the plate

$$\boxed{\theta = \sin\left(\frac{h}{l}\right)}$$

Figure 2: Forming an Angle with a Sine Bar and Gauge Blocks

WRINGING

The term wringing refers to a condition of intimate and complete contact by tight adhesion between measuring faces. Wringing is done by hand by sliding and twisting motions. One gauge is placed perpendicular to other using standard gauging pressure then a rotary motion is applied until the blocks are lined up. In this way air is expelled from between the gauge faces causing the blocks to adhere. This adherence is caused partially by molecular attraction and partially by atmospheric pressure. Similarly, for separating slip gauges, a combined sliding and twisting motion should be used.

1. To set an angle on any sine bar, you must first determine the center distance of the sine bar (C), the angle you wish to set (A) and whether the angle is in degrees-minutes-seconds or decimal degrees.

2. Next, enter that information in the appropriate input areas below. Use a decimal point for the separator, whether the angle is in degrees-minutes-seconds or decimal degrees.

3. Hit the 'Calculate' button and then assemble a stack of gauge blocks (G) to equal the size that is returned. The units of the stack will match the units of the center distance (i.e., If you enter the center distance as 5 for a 5 inch sine plate, the gage block stack will also be in inches.).

4. Place these slip gauges blocks under the gauge block roll of the sine device and the desired angle is set.

5. Tighten the locking mechanism on those devices that have one and you're ready to go.

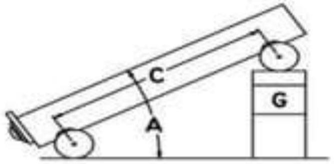
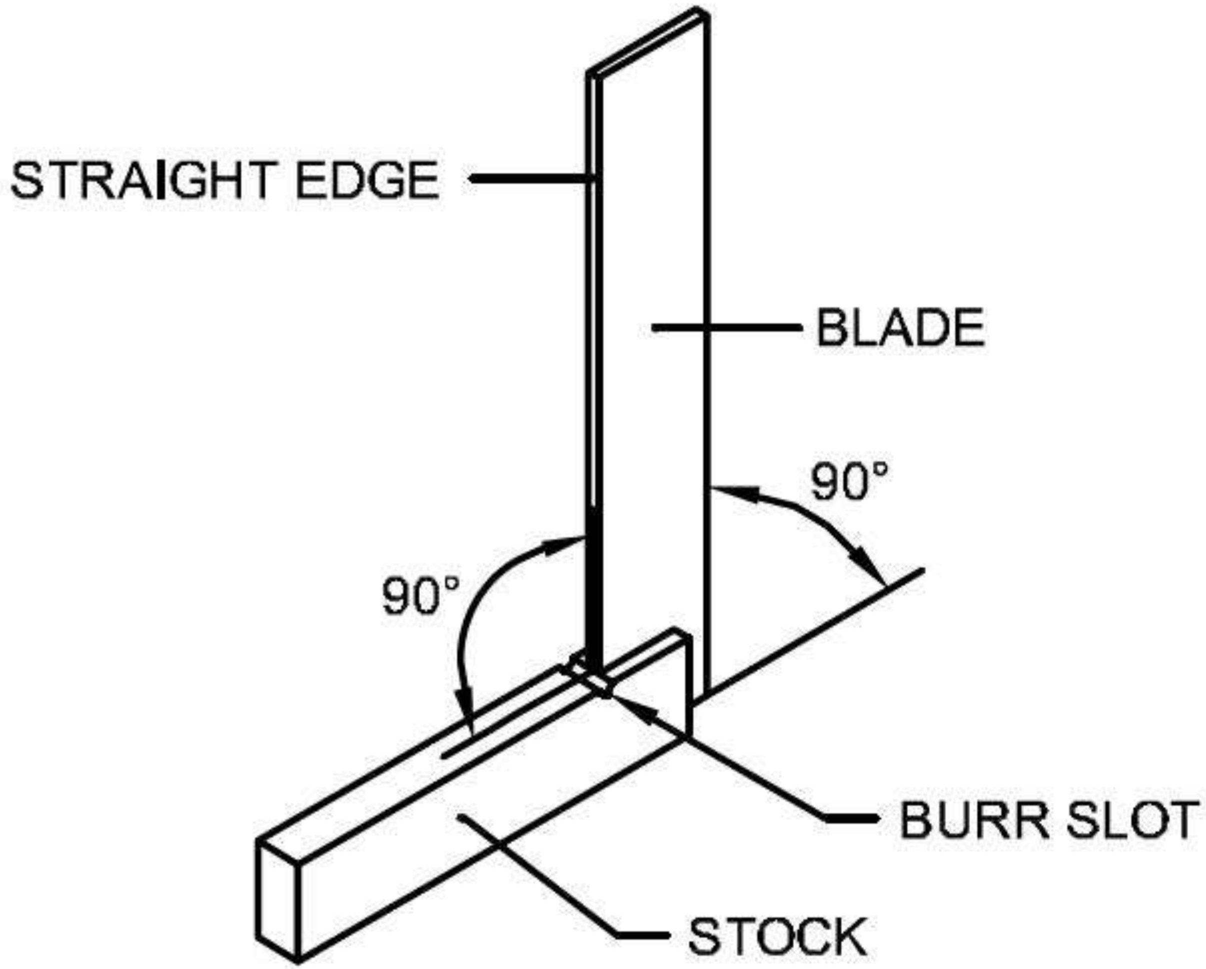


Figure 3: Uses the formula: G = C * Sin(A)


STRAIGHT EDGE
BLADE
90°
90°
BURR SLOT
STOCK

UNIT 5

SURFACE ROUGHNESS MEASUREMENT

INTRODUCTION:

Surface roughness measurement is a value calculated by measuring the average of heights and depths across a processed surface. Measuring surface roughness is integral to determining the compliance of equipment and products with industry regulations

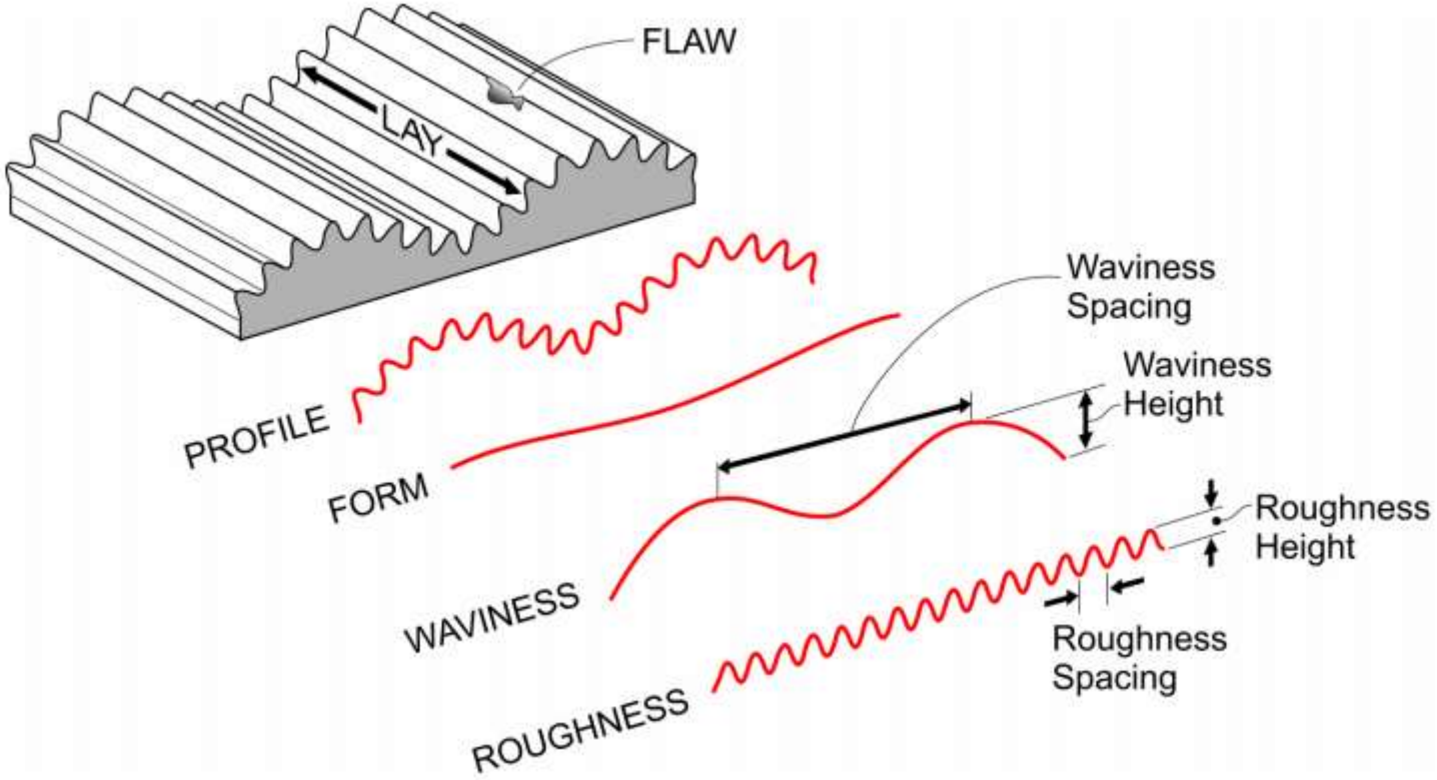
Definition:

Measuring surface roughness is done with a profilometer or laser scanner. The greater the deviations, the rougher the surface and if the Ra is small, the surface is smooth. The Ra will be calculated in micrometers (µm) or microinches (µin.).

s**urface roughness** or **roughness** is defined as the irregularities which are inherent in the production process (e.g. cutting tool or abrasive grit). Surface **roughness** is quantified by the deviations in the direction of the normal vector of a real surface from its ideal **form**. If these deviations are large, the surface is rough; if they are small, the surface is smooth.

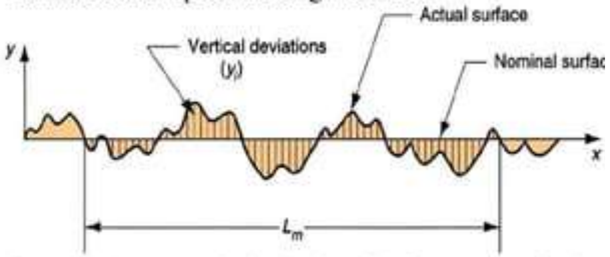
Roughness: includes the finest (shortest wavelength) irregularities of a surface. Roughness generally results from a production process or material condition.

Ra (way to define roughness) – Average Roughness Also known as Arithmetic Average (AA), Center Line Average (CLA), Arithmetical Mean Deviation of the profile. The average roughness is the area between the roughness profile and its mean line, or the integral of the absolute value of the roughness profile height over the evaluation length.


FLAW
LAY
PROFILE
FORM
WAVINESS
ROUGHNESS
Waviness Spacing
Waviness Height
Roughness Height
Roughness Spacing

Surface Roughness

Average of vertical deviations from nominal surface over a specified length surface.



Sampling Length: It is the length of Profile necessary for the evaluation of irregularities to be taken in account. Also called as

Mean line of the Profile: It is the line that divides th profile such that, within sampling length the sum of vertical ordinates (y1,y2....) between effective profile poi line is minimum or

Center line of the Profile: It is the line that divides th profile such that, the area contained by the profile abov the line are equal.

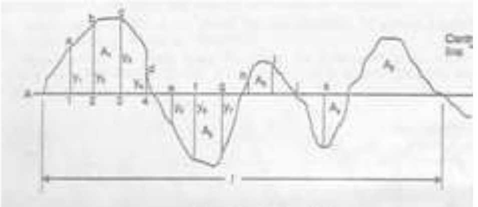


Fig. 11.4. Surface Roughness

Mean line of the Profile: It is the line that divides th

WAVINESS

Waviness: Waviness is a recurrent deviation from a flat surface, much like waves on the surface of water. It is measured and described in terms of the surface between adjacent crests of the waves (waviness width) and height between the crests and valleys of the waves (waviness height).

The factors affecting surface waviness:

a) deflection of tools, dies or the work piece

b) force or temperature sufficient to cause warping

c) uneven lubrication

d) vibration

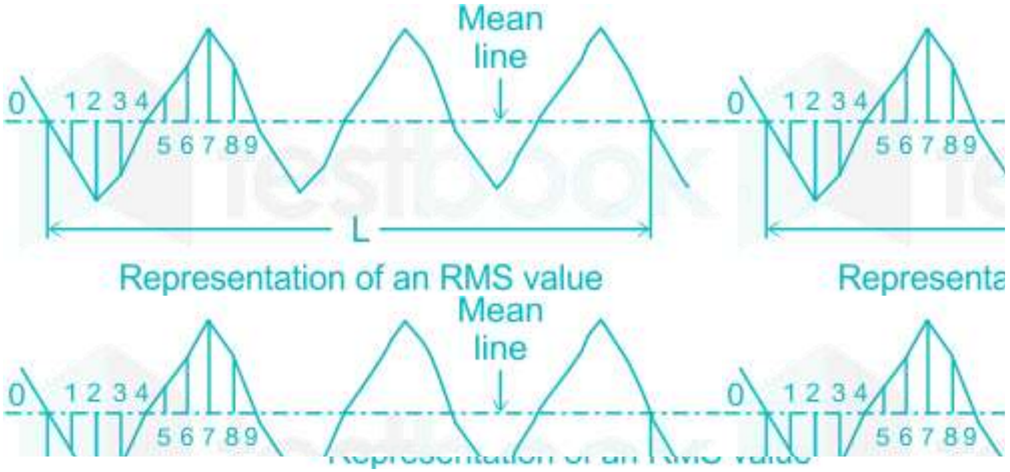
e) any periodic mechanical or thermal variations on the system during manufacturing operations.

WAVINESS

Waviness: Waviness is a recurrent deviation from a flat surface, much like waves on the surface of water. It is measured and described in terms of the surface between adjacent crests of the waves (waviness width) and height between the crests and valleys of the waves (waviness height).

The factors affecting surface waviness:

Representation of an rms value:



Definition:

THE RMS VALUES POPULAR CHOICE FOR QUANTIFY SURFACE ROUGHNESS THIS HAS BEEN SUPESTED by the centre line the average values the rms values defined as been square root of the mean square of the orientation of the surface measurement from the line

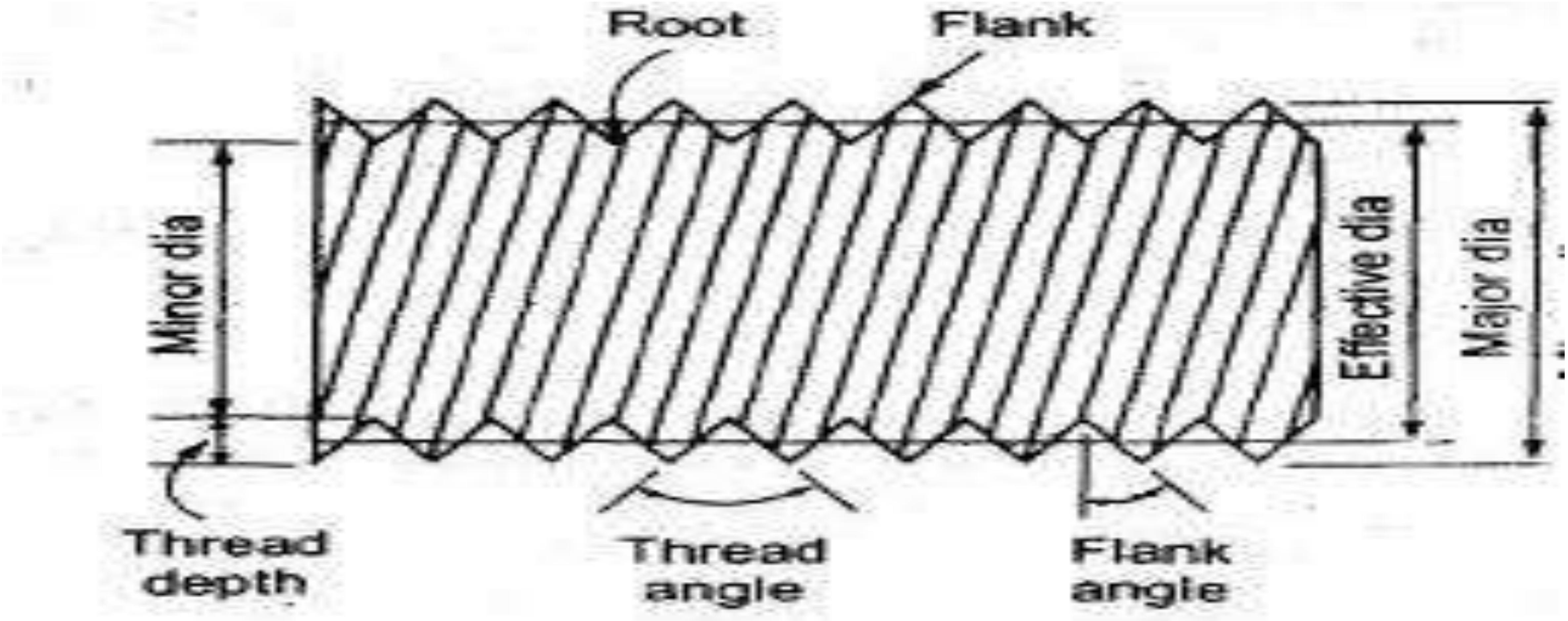
SCREW THREAD MEASUREMENT

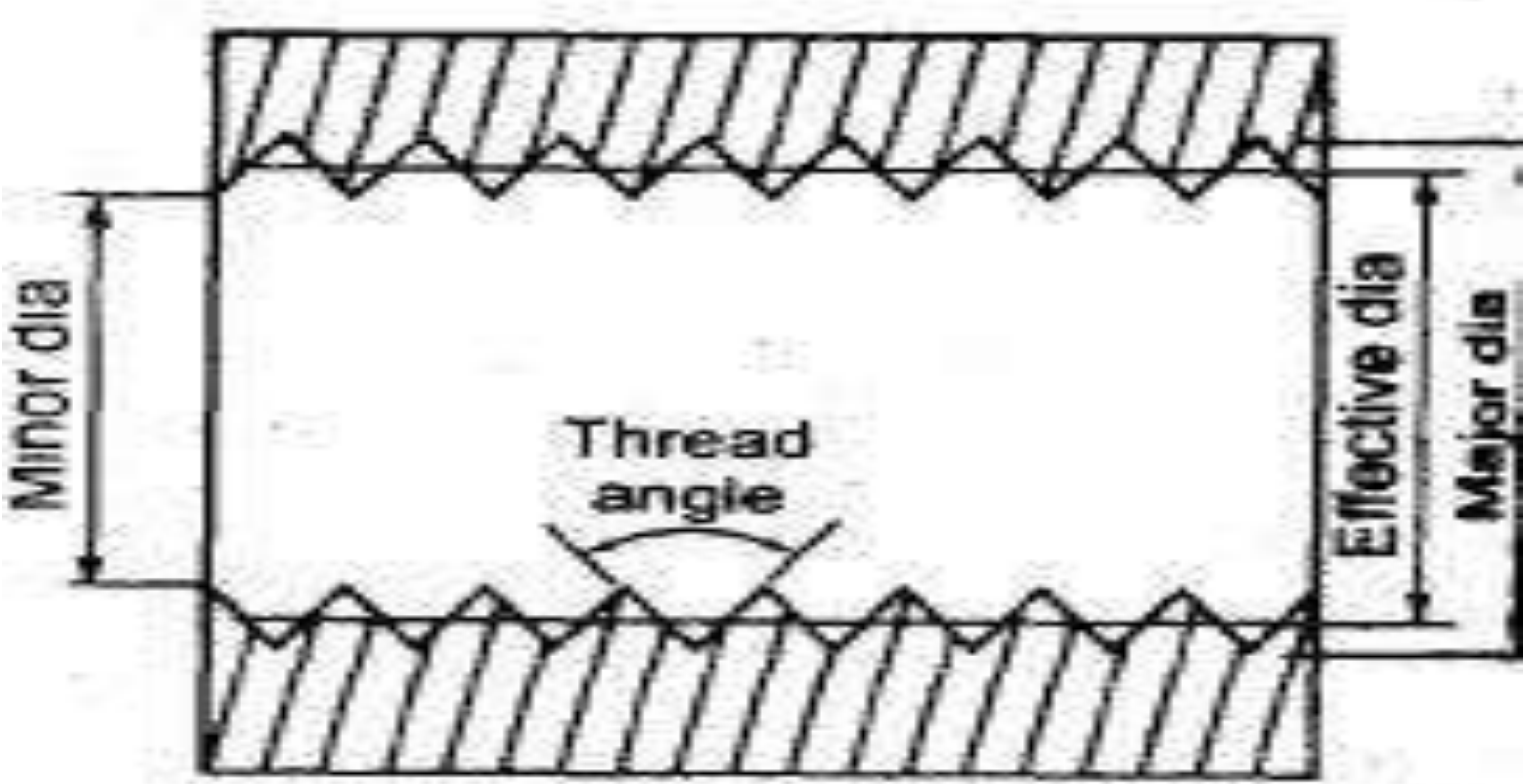
➢ Screw threads are used to transmit the power and motion, and also used to fasten
two components with the help of nuts, bolts and. studs.

➢ There is a large variety of screw threads varying in their form, by included angle,
head angle, helix angle etc.

The screw threads are mainly classified into

1) External thread
2) Internal thread



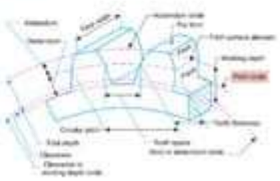

Minor dia
Thread
angle
Effective dia
Major dia

Gear Measurement

1. Gear Runout Measurement

It means eccentricity in the pitch circle. It will give periodic vibration during each revolution of the gear. This will give the tooth failure in gears. The run out is measured by means of eccentricity testers.

In the testing the gears are placed in the mandrel and the dial indicator of the tester possesses special tip depending upon the module of the gear and the tips inserted between the tooth spaces and the gears are rotated tooth by tooth and the variation is noted from the dial indicator.



Gear
1. Gear R
It means
each revol
out is meas
In the tes
the mandr
the teste
depending
gear and t
tooth spac
tooth by
noted fron